held their meeting at Manchester, the complaint which they brought against the Science and Art Department of breach of faith, and repudiation of engagements made with them, has been pressed upon the Government by a strong force of Lancashire and Yorkshire members of Parliament.

THE *British Medical Journal* states that Prof. Agassiz is ill from nervous prostration and over-work, not being able even to write letters.

THE Gulstonian Lectures for this year will be delivered at the Royal College of Physicians, by Dr. Maudsley, on the 11th, 16th, and 18th of this month, the subject being "The Relations between Body and Mind, and between Mental and other Nervous Disorders." The Croonian Lectures will be on "Aneurism of the Heart," and will be delivered by Dr. Gibson on the 23rd, 25th, and 30th of March. The subject of the Lumleian Lectures on the 1st, 6th, and 8th of April, will be "The Natural History and Diagnosis of Intra-Thoracic Cancer," by Dr. J. R. Bennett. The lectures will commence in each case at 5 o'clock.

THE Acclimatation Society of Paris has awarded to Mr. P. L. Simmonds its silver medal, of the first class, for his paper on "Silk cultivation and supply," read before the Indian Conference of this Society last year. A similar medal has been awarded to Mr. G. W. Hart, of Hayling Island, for his labours in oyster culture.

THE Instituto Tecnico of Palermo has published another part of the *Giornale di Scienze Naturali ed Economiche*, which well sustains the character of the work. Among the papers therein contained we notice—"Avifauna del Modenese e della Sicilia," "Sui materiali per costruzione di mattoni refrattarii per le zolfare," "Nuove specie di funghi," "Determinazione del luogo chimico nelle sostanze aromatache," and "Studii palæontologici sulla fauna del calcario a telebratula janitor del nord di Sicilia." Besides all this, the part contains eight numbers of the *Bulletino* of the Royal Astronomical Observatory at Palermo, in which are records of observations astronomical and meteorological, notices of sun-spots and magnetic perturbations, and on shooting-stars and meteors, with lithographic illustrations. It is gratifying to find that even in Sicily science is making progress.

THE Government of India has lately sanctioned the commencement of the Damoodah Canal, at an estimated cost of about 540,000*l*. Its total length will be just 100 miles. One end of it will terminate in the heart of the Bengal coal-fields, and it will thus be the means of affording a cheap line of transport for carrying coals into Calcutta, relieving at the same time the railway of a portion of that traffic. A secondary but very important result of this canal is likely to be the drainage of the tract of land lying between the railway and the Damoodah, which for the last seven years has been desolated by malarious fever.

WE learn that the success of the Lectures for Women during the present term has equalled the most sanguine expectations of the originators of the scheme. Between seventy and eighty ladies are now attending eight courses of lectures, the number of attendances (counting each lecture separately) being in all 115. The committee proposes to issue in June a complete programme of the lectures for the next academical year. The present courses will be continued during the next (Easter) term at the present hours, unless special notice of a change be given.

WE have received from the Hydrographic Office of the Admiralty a copy of the notice to mariners stating that, on or about the 1st of April next, a telegraphic station vessel will be moored by the International Mid-Channel Telegraph Company off the entrance to the English Channel, in from fifty-five to fifty-nine fathoms water, in lat. 49° 20′ 30″ N., long. 6° 17′ W. of Greenwich. The vessel will be painted black, with the words "Telegraph Ship" in white letters on her sides; she will have three masts. At the top of the mainmast a large black cone will be hoisted during daytime, and a powerful globular light at night, elevated thirty feet above the sea, which in clear weather should be seen from a distance of six miles. A flare-up light will also be shown every fifteen minutes during the night, from an hour after sunset to an hour before sunrise. During foggy weather, day or night, a bell will be rung continuously for half a minute every quarter of an hour; and for the first six months, or until the 1st day of October 1870, a gun will be fired every quarter of an hour, and after that date every hour. The commercial code of signals for the use of all nations will be used on board, to the exclusion of all other codes, and none other can be noticed. In reference to this, M. Delehaye remarks in the *Bulletin* of the Association Scientifique of France that it will be of great service to navigation by saving time, and obviating risk and expense. For meteorological purposes also he believes this station will be very useful. He might have extended his list.

ON THE TEMPERATURE AND ANIMAL LIFE OF THE DEEP SEA*

I.

THE present discourse embodies the most important general results obtained by the exploration of the deep sea in the neighbourhood of the British Isles, carried on during the summer of 1869 in H.M. surveying vessel *Porcupine*, with the view of completing and extending the inquiries commenced in the *Lightning* expedition of 1868, of which an account was given by the speaker at the Friday evening meeting of April 9, 1869.†

The expedition of the *Porcupine* was divided into three cruises. The first of these, which was placed under the scientific charge of Mr. J. Gwyn Jeffreys, F.R.S., accompanied by Mr. William L. Carpenter, as chemical assistant, commenced from Galway near the end of May, and concluded at Belfast at the beginning of July. It was directed in the first instance to the south-west, then to the west, and finally to the north-west as far as the Rockall Bank. The greatest depth at which temperature-sounding and dredging were carried on in this cruise was 1,476 fathoms; and these operations, through the excellent equipment of the *Porcupine* and the skill of her commander, Captain Calver, were so successfully performed, that it was confidently anticipated that still greater depths might be reached with an equally satisfactory result.

The second cruise, which was under the scientific charge of Prof. Wyville Thomson, F.R.S., with Mr. Hunter as chemical assistant, was consequently directed to the nearest point at which a depth of 2,500 fathoms was known to exist, viz., the northern extremity of the Bay of Biscay, about 250 miles to the west of Ushant. In this cruise temperature-sounding and dredging were carried down to the extraordinary depth of 2,345 fathoms, or nearly three miles—a depth nearly equal to the height of Mont Blanc, and exceeding by more than 500 fathoms that from which the Atlantic Cable was recovered. This sea-bed, on which the pressure of the superincumbent water is nearly three tons for every square inch, was found to support an abundance of animal life; about 1½ cwt. of "Atlantic mud," chiefly consisting of *Globigerinæ*, having been brought up in the dredge, together with various types of higher animals, Echinoderms, Annelids, Crustaceans, and Mollusks; among them a new Crinoid—referable, like the *Rhizocrinus*, whose discovery by M. Sars, jun., had been the starting-point of the present inquiry—to the *Apiocrinite* type which flourished during the Oolitic period.

The third cruise was under the scientific charge of the speaker, with Mr. P. H. Carpenter as chemical assistant; but he had the great advantage of being accompanied by his colleague Prof. Wyville Thomson, who, as in the *Lightning* expedition, took the entire superintendence of the dredging operations. The object of this cruise, which commenced in the middle of August and terminated in the middle of September, was a more thorough exploration of the area between the North of Scotland and the Faroe Islands, which had been found in the *Lightning* expedition to afford results of peculiar interest in regard alike to the inequality of temperature and to the distribution of animal life on the sea-bed, which here ranges between the comparatively shallow depths of from 350 to 650 fathoms—the last-named being the greatest depth to which dredging had been carried in 1868.

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* A Lecture delivered at the Royal Institution.

† Proceedings of the Royal Institution, vol. v. p. 503.

The weather, during nearly the whole of the *Porcupine* expedition, was as favourable to its work, as during the greater part of the *Lightning* expedition it had been unfavourable; and the results obtained not only far exceeded the most sanguine expectations of those who had promoted it, but may be said, without exaggeration, to be such as no previous scientific exploration of so limited an extent and duration is known to have yielded.

The results of the temperature-soundings will be first stated, with their bearing on the doctrines advanced in the former discourse as probable inferences from the observations made during the *Lightning* expedition. These observations indicated that two very different submarine climates exist in the deep channel which lies E.N.E. and W.S.W. between the North of Scotland and the Faroe Banks; a minimum temperature of 32° having been registered in some parts of this channel, whilst in other parts of it, at the like depths, and with the same surface temperature (never varying much from 52°), the minimum temperature registered was never lower than 46°,—thus showing a difference of 14°. It could not be positively asserted that these minima are the bottom-temperatures of the Areas in which they respectively occur: but it was argued that they must almost necessarily be so:—first, because it is highly improbable that sea-water at 32° should overlie water at any higher temperature, which is specifically lighter than itself, unless the two strata have a motion in opposite directions sufficiently rapid to be recognisable; and secondly, because the nature of the animal life found on the bottom of the cold area, which consists of quartzose sand including volcanic particles, exhibited a marked correspondence with its presumed reduction of temperature, whilst the sea-bed of the warm area is essentially composed of *Globigerina*-mud, and the animal life which it supports is characteristic of the warmer-temperate seas.

This conclusion, it is obvious, would not be invalidated by any error arising from the effect of pressure on the bulbs of the thermometers; since, although the actual minima might be, as was then surmised, from 2° to 4° below the recorded minima, the difference between temperatures taken at the same or nearly the same depths would remain unaffected.

The existence in the cold area, of a minimum temperature of 32°, with a Fauna essentially Boreal, could not, it was argued, be accounted for in any other way than by the supposition of an under-current of Polar water coming down from the north or north-east: whilst, conversely, the existence in the warm area, of a minimum temperature of 46°, extending to 500 or 600 fathoms' depth, in the latitude of 60° (being at least 8° above its isotherm), together with the warmer-temperate character of its Fauna, seemed equally indicative of a flow of equatorial waters from the south or south-west.

It was further urged that if the existence of two such different submarine climates in close proximity can only be accounted for on the hypothesis of an Arctic stream and an Equatorial stream running side by side (the latter also spreading over the former in consequence of its lower specific gravity), these streams are to be regarded (like the Gulf Stream) as particular cases of a great general Oceanic Circulation, which is continually bringing the water cooled-down in the Polar regions into the deepest parts of the Equatorial ocean-basins, whilst the water heated in the Equatorial regions moves towards the poles on or near the surface. Such a circulation was long since pointed out to be as much a physical necessity, as that interchange of *Air* between the Equatorial and Polar regions which has so large a share in the production of winds; but whilst physical geographers remained under the dominant idea that the temperature of the deep sea is everywhere 39°, they could not fully recognise its importance.

These doctrines have been fully tested by the very numerous and careful temperature-soundings taken in the *Porcupine* expedition; and the result has been not merely to confirm them in every particular—so that they may now take rank as established facts,—but also to show that a temperature 2½° below the freezing-point of fresh water may prevail over the sea-bed in a region far removed from the Polar, and that even this extreme reduction is by no means antagonistic to the existence of animal life in great variety and abundance.

All the temperature-soundings of the *Porcupine* expedition were taken with thermometers protected from the effects of pressure by the enclosure of the bulb of each instrument in an outer bulb, sealed round the neck of the tube; about three-fourths of the intervening space being filled with spirit, but a small vacuity being left, by which any reduction in the capacity of the outer bulb is prevented from communicating pressure to the inner. This plan of construction, which was suggested by Prof. W. A. Miller, has been so successfully carried into practice by Mr. Casella, that thermometers thus protected have been subjected to a pressure of three tons on the square inch, in a testing-machine devised for the purpose, without undergoing more than a very slight elevation, of which a part, at least, is attributable to the heat given out by the compression of the water in which they were immersed: whilst the very best thermometers of the ordinary construction were affected by the same pressure to the extent of 8° or 10°, the elevation in some instruments reaching as much as 50° or 60°.* Two of these protected Miller-Casella thermometers were used in each observation, and they always agreed within a fraction of a degree. The same pair was used throughout the expedition; and notwithstanding that they were used for 166 separate observations, in which they travelled up and down nearly 100 miles, they came back in perfectly good order; a result mainly due to the care with which they were handled by Captain Calver. It may be affirmed with great confidence that the temperatures which they indicated were correct within 1° (Fahr.); an approximation quite near enough for the scientific requirements of the case.

In order to connect the work of the *Porcupine* with that of the *Lightning* expedition, it will be desirable to commence with the third cruise of the former, in which a detailed survey was made of the area traversed in the preceding year by the latter. In this cruise bottom-soundings were taken at thirty-six different stations, at depths varying from 100 to 767 fathoms; of these, seventeen were in the cold area and fourteen in the warm, whilst five exhibited intermediate temperatures, in accordance with their border position between the two. In order to ascertain whether the minimum temperatures thus obtained were really the temperatures of the bottom, serial soundings were taken at three stations, of which one was in the warm area and two in the cold—the temperature at different depths between the surface and the bottom being ascertained by successive observations, at the same points, at intervals of 50 or 100 fathoms. All these results agreed extremely well with each other; and they closely accorded with the fifteen observations made in the *Lightning* expedition, when the requisite correction for pressure (from 2° to 3° according to the depth) was applied to the latter.

The following general summary of these results brings into marked contrast the conditions of the warm and cold areas, which occupy respectively the W.S.W. and E.N.E. portions of the Channel between the north of Scotland and the Faroe Islands, and lie side by side in its midst.

The surface-temperature may be said to be everywhere nearly the same, viz. 52°; the variations above and below this being attributable either to atmospheric differences (as wind, sunshine, &c.) or to difference of latitude. Alike in the warm and the cold areas there was a fall of from 3° to 4° in the first 50 fathoms, bringing down the temperature at that depth to 48°. A slow descent took place nearly at the same rate in both areas through the next 150 fathoms; the temperature in the warm area at the depth of 200 fathoms being 47°, whilst in the cold it was 45·7°. It is below this depth that the marked difference shows itself. For whilst in the warm area there is a slow and pretty uniform descent in the next 400 fathoms, amounting to less than four degrees in the whole, there is in the cold area, a descent of fifteen degrees in the next 100 fathoms, bringing down the temperature at 300 fathoms to 30·8°. Even this is not the lowest; for the serial soundings taken at depths intermediate between 300 and 640 fathoms (the latter being the greatest depth met with in the cold area, midway between the Faroe and the Shetland Islands) showed a further progressive descent; the lowest bottom-temperature met with being 29·6°. Thus, while the temperature of the superficial stratum of the water occupying the cold area clearly indicates its derivation from the same source as the general body of water occupying the warm area, the temperature of the deeper stratum, which may have a thickness of more than 2,000 feet, ranges from the freezing point of fresh water to 2½° below it. Between the two is a stratum of intermixture of about 100 fathoms thickness, which marks the transition between the warm superficial layer and the body of frigid water which occupies the deeper part of the channel.

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* See Prof. W. A. Miller's "Note upon a Self-Registering Thermometer, adapted to Deep Sea Soundings," in "Proceedings of the Royal Society," June 17, 1869.—The same principle had been previously applied in thermometers constructed under the direction of Admiral Fitzroy; the space between the two bulbs, however, being occupied with mercury instead of spirit. Owing, however, to some imperfection in their construction, their performance was not satisfactory, and they were found very liable to fracture.

The shortest distance within which these two contrasted submarine climates were observed at corresponding depths, was about 20 miles; but a much smaller distance was sufficient to produce it when the depth rapidly changed. Thus near the southern border of the deep channel, at a depth of 190 fathoms, the bottom-temperature was 48·7°; while only six miles off, where the depth had increased to 445 fathoms, the bottom-temperature was 30·1°. In the first case, the bottom evidently lay in the warm superficial stratum; whilst in the second it was overflowed by the deeper frigid stream.

It seems impossible to account for these phenomena on any other hypothesis than that of the direct derivation of this frigid water from the Arctic basin. And this agrees very well with other facts observed in the course of the exploration. Thus:—(1) The rapid descent of temperature marking the "stratum of intermixture" began about 50 fathoms nearer the surface in the most northerly portion of the cold area examined, than it did in the most southerly, as might be expected from the nearer proximity of the cold stream to its source. (2) The sand covering the bottom contains particles of volcanic minerals, probably brought down from Jan Mayen or Spitzbergen. (3) The Fauna of the cold area has a decidedly Boreal type; many of the animals which abound in it having been hitherto found only on the shores of Greenland, Iceland, or Spitzbergen.

Although the temperatures obtained in the warm areas do not afford the same striking evidence of the derivation of its whole body of water from a southern source, yet a careful examination of its condition seems fully to justify such an inference. For the water at 400 fathoms in lat. 59½° was only 2·4° colder than water at the same depth at the northern border of the Bay of Biscay, in a latitude more than 10° degrees to the south, where the surface-temperature was 62·7°; and the approximation of the two temperatures is yet nearer at still greater depths, the bottom-temperature at 767 fathoms at the former stations being 41·4°, whilst the temperature at 750 fathoms at the latter point was 42·5°. Now, as it may be certainly affirmed that the lowest temperature observed in the warm area is considerably above the isotherm of its latitude, and that this elevation could not be maintained against the cooling influence of the Arctic stream but for a continual supply of heat from a warmer region, the inference seems inevitable that the bulk of the water in the warm area must have come thither from the S.W. The influence of the Gulf Stream proper (meaning by this the body of superheated water which issues through the "Narrows" from the Gulf of Mexico), if it reaches this locality at all—which is very doubtful—could only affect the most superficial stratum; and the same may be said of the surface-drift caused by the prevalence of south-westerly winds, to which some have attributed the phenomena usually accounted for by the extension of the Gulf Stream to these regions. And the presence of the body of water which lies between 100 and 600 fathoms' depth, and the range of whose temperature is from 48° to 42°, can scarcely be accounted for on any other hypothesis than that of a great general movement of Equatorial water towards the Polar area; of which movement the Gulf Stream constitutes a peculiar case modified by local conditions. In like manner, the Arctic Stream which underlies the warm superficial stratum in our cold area, constitutes a peculiar case, modified by the local conditions to be presently explained, of a great general movement of Polar water towards the Equatorial area, which depresses the temperature of the deepest parts of the great Oceanic basins nearly to the freezing-point.

W. B. CARPENTER

SOCIETIES AND ACADEMIES

LONDON

Royal Society, March 3.—The following papers were read:—"Results of the Monthly Observations of Dip and Horizontal Force, made at the Kew Observatory, from April 1863 to March 1869 inclusive." By Dr. Balfour Stewart. "Spectroscopic observations on stars and nebulæ made with the Great Melbourne Telescope." By A. Le Sueur. "On the nebula of Argo, and on the spectrum of Jupiter." By A. Le Sueur. We shall return to these papers next week.

Geological Society, February 18.—Annual general meeting, Prof. T. H. Huxley, president, in the chair. The secretary read the Reports of the Council, of the Library and Museum Committee, and of the Auditors. The general position of the society, as evinced by the state of its finances, and by the continued increase in the number of its members, was stated to be very satisfactory. In presenting the Wollaston Gold Medal to John Evans, Esq,, for transmission to M. G. P. Deshayes, the president requested him to transmit it to M. Deshayes as an expression on the part of the Geological Society of the high estimation in which his services to palæontology and geology, especially in regard to the classification of the tertiary formation, are held by the geologists of this country; adding, that six years ago the council of this society demonstrated the interest which it took in M. Deshayes's valuable investigations by awarding him the Donation-fund. Now that those researches, commenced just fifty years ago, are completed, and the labours of a life devoted to science are crowned by the publication of five great volumes containing descriptions and figures of all the mollusca of the Paris basin, it has seemed to the Council a fitting opportunity for bestowing the highest honour at its disposal upon the pupil, editor, and continuator of Lamarck, and the worthy successor of his great master in the Chair of Natural History in the Muséum d'Histoire Naturelle. Mr. Evans acknowledged on the part of M. Deshayes, the award of the Wollaston Medal, and read a letter from M. Deshayes expressing his sense of the honour conferred upon him. The president presented the balance of the proceeds of the Wollaston Donation-fund to Mr. Evans, for transmission to M. Rouault, Keeper of the Geological Museum at Rennes, in aid of his researches upon the Palæontology of the Devonian and Silurian Rocks of Brittany, and remarked that the cosmopolitanism of science was well illustrated by the fact that all the honours at the disposal of the society this year are gladly accorded to foreigners.—The President then read his anniversary address, prefaced by biographical notices of deceased Fellows, including Prof. Brayley, F.R.S.; Dr. Hermann von Meyer; Dr. B. Shumard; Dr. Roget, F.R.S.; Prof. Graham, F.R.S.; Prof. Jukes, F.R.S.; Dr. W. Clarke, F.R.S.; Mr. J. W. Salter; the Vicomte d'Archiac, &c. The ballot for the council and officers was taken, and the following were duly elected for the ensuing year:—President: Mr. Joseph Prestwich. Vice-Presidents: Sir P. de M. G. Egerton, R. A. C. Godwin-Austen, Sir Charles Lyell, Bart., Warrington W. Smyth. Secretaries: P. Martin Duncan, John Evans. Foreign Secretary: Professor D. T. Ansted. Treasurer: J. Gwyn Jeffreys. Council: Prof. D. T. Ansted, William Carruthers, W. Boyd Dawkins, P. Martin Duncan, Sir P. de M. G. Egerton, John Evans, David Forbes, J. Wickham Flower, Capt. Douglas Galton, R. A. C. Godwin-Austen, Harvey B. Holl, J. Whitaker Hulke, Prof. T. H. Huxley, J. Gwyn Jeffreys, Sir Charles Lyell, George Maw, John Carrick Moore, Prof. John Morris, Joseph Prestwich, Warrington W. Smyth, Rev. W. S. Symonds, Rev. Thomas Wiltshire, Henry Woodward.

Zoological Society, February 24.—Dr. E. Hamilton, V.P. in the chair. A communication was read from Mr. R. Swinhoe containing some information on the subject of the exact locality of the Amherst's pheasant (*Thaumalea amherstiæ*), which was stated to be the mountains between the Chinese province of Sechuen and Tibet.—A letter was read from Sir George Grey in reference to Professor Owen's communication of a letter from Dr. Haast read at the previous meeting. Sir G. Grey was of opinion that there were good grounds for believing that the *Dinornis* had been extirpated by the direct ancestors of the present race of Maories.—A second letter was read addressed to the Secretary by Mr. W. H. Hudson on the ornithology of Buenos Ayres.—Mr. Sclater exhibited a specimen of a new lemur, which had been lately discovered by Mr. Van Dam in North-eastern Madagascar, and had been named by Mr. Pollen *Propithecus damanus*.—Messrs. C. H. T. and G. F. L. Marshall read some notes on the classification of the birds of the family *Capitonidæ*.—Two communications were read from Mr. R. Swinhoe on the white wag-tails (*Motacillæ*) of China, and on a new species of *Accentor* from Northern China proposed to be called *A. erythropygius*.—Mr. P. L. Sclater read a paper on the deer living in the Society's menagerie, amongst which there were stated to be examples of several recently described and very little known species. Mr. Sclater concluded his paper with remarks on the arrangement and the geographical distribution of the *Cervidæ*, and in particular of the species of the genus *Cervus*. The total number of *Cervi* recognised as probably